

Topic 19 Organisms and their Environment

19.1 Energy Flow

The **Sun** is the principal source of energy input to all biological systems.

Flow of Energy

Energy flows through living organisms in the following way:

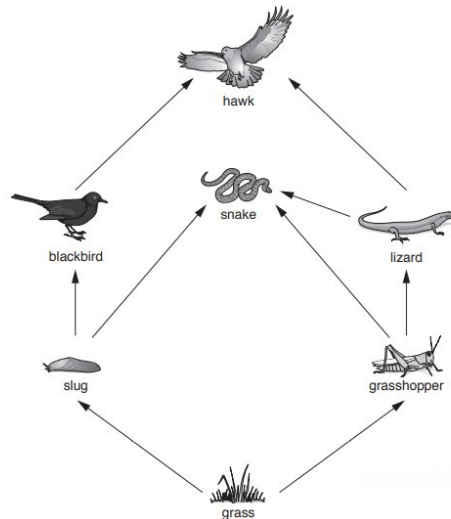
- 1 **Light Energy** from the Sun is absorbed by **producers** (plants and algae).
 - 2 Producers convert light energy into **chemical energy** (in the form of organic molecules like glucose) via **photosynthesis**.
 - 3 This chemical energy is transferred to **consumers** when they feed on other organisms.
 - 4 At every stage (producer, consumer), a large amount of energy is **lost** to the environment as **heat** during **respiration**, or through **waste products** (faeces, urine).
 - 5 Eventually, all energy is transferred to the environment as heat.
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19.2 Food Chains and Food Webs

Definitions

Term	Definition
Food Chain	Shows the transfer of energy from one organism to the next, beginning with a producer .
Food Web	A network of interconnected food chains showing the feeding relationships in an ecosystem.
Producer	An organism that makes its own organic nutrients, usually by photosynthesis .
Consumer	An organism that gains energy by feeding on other organisms.
↳ Herbivore	An animal that eats plants (primary consumer).

Term	Definition
↳ Carnivore	An animal that eats other animals (secondary, tertiary, or quaternary consumer).
Decomposer	An organism (e.g., bacteria, fungi) that feeds on dead or waste organic material (e.g., faeces) and breaks it down.



Trophic Levels

A **trophic level** is the position of an organism in a food chain, food web, or pyramid.

Trophic Level	Organism Type	Example
Trophic Level 1	Producers	Grass
Trophic Level 2	Primary Consumers (Herbivores)	Grasshopper
Trophic Level 3	Secondary Consumers (Carnivores/Omnivores)	Frog
Trophic Level 4	Tertiary Consumers (Carnivores/Omnivores)	Snake
Trophic Level 5	Quaternary Consumers (Top Carnivores)	Eagle

Pyramids

Pyramids are used to represent the flow of energy or the number/mass of organisms at each trophic level.

Pyramid Type	What it Measures	Advantage/Disadvantage
Numbers	The number of individual organisms at each trophic level.	Disadvantage: Can sometimes be inverted or oddly shaped (e.g., one large tree supporting many insects).
Biomass	The total mass of living material (biomass) at each trophic level.	Advantage: Shows the actual amount of living tissue. Usually a true pyramid shape.
Energy	The amount of energy transferred to each trophic level over a period of time.	Advantage: Always a true pyramid shape, as energy is lost at each level. Preferred over numbers or biomass as it represents the energy flow more accurately.

Energy Transfer

Energy transfer between trophic levels is **inefficient**, with only about **10%** of the energy from one level being transferred to the next.

Reasons for Energy Loss (90%):

- 6 **Not all of the organism is eaten** (e.g., roots, bones, shells).
- 7 **Energy is lost in waste products** (faeces, urine).
- 8 **Energy is lost as heat during respiration** for **movement, growth, and maintaining body temperature**.

Because of this large energy loss, food chains usually have **fewer than five trophic levels**, as there is not enough energy remaining to support a higher trophic level.

Energy Efficiency and Humans: It is more energy efficient for humans to eat **crops directly** (primary consumer level) rather than **livestock fed on crops** (secondary consumer level). This is because a significant amount of energy is lost when the crop is fed to the animal.

19.3 Nutrient Cycles

The Carbon Cycle

The carbon cycle describes how carbon is recycled between living organisms and the environment.

Processes Involved:

- 1 **Photosynthesis:** Producers (plants) remove CO_2 from the atmosphere to make organic molecules (glucose).
- 2 **Feeding:** Carbon compounds are transferred to consumers when they eat producers.
- 3 **Respiration:** All living organisms (producers, consumers, decomposers) release CO_2 into the atmosphere as they break down organic molecules for energy.
- 4 **Decomposition:** Decomposers break down dead organisms and waste products, releasing CO_2 via respiration.
- 5 **Fossil Fuel Formation:** Carbon from dead organisms is converted into fossil fuels (coal, oil, gas) over millions of years under heat and pressure.
- 6 **Combustion:** Burning of fossil fuels and wood releases CO_2 into the atmosphere.

The Nitrogen Cycle

The nitrogen cycle describes how nitrogen is recycled between living organisms and the environment. Nitrogen is essential for making **amino acids** and **proteins**.

Processes and Microorganisms Involved:

- 1 **Decomposition (Ammonification):**
 - Decomposers break down dead organisms and waste products, converting the nitrogen in proteins and urea into **ammonium ions** (NH_4^+).
- 2 **Nitrogen Fixation:**
 - **Lightning:** Converts atmospheric nitrogen gas (N_2) into nitrates (NO_3^-).
 - **Nitrogen-fixing bacteria** (found in soil or in the root nodules of legumes) convert N_2 into ammonium ions (NH_4^+).
- 3 **Nitrification:**
 - **Nitrifying bacteria** convert ammonium ions (NH_4^+) into nitrites (NO_2^-), and then into **nitrates** (NO_3^-).
- 4 **Absorption (Assimilation):**
 - Plants absorb **nitrates** (NO_3^-) from the soil and use them to make amino acids and proteins.
 - These are transferred to animals through **feeding**.
- 5 **Denitrification:**
 - **Denitrifying bacteria** in waterlogged or anaerobic soil convert nitrates (NO_3^-) back into atmospheric nitrogen gas (N_2), completing the cycle.

19.4 Populations

Definitions

Term	Definition
Population	A group of organisms of one species living in the same area at the same time.
Community	All the populations of different species living in the same area at the same time.
Ecosystem	The community of organisms and their non-living (abiotic) environment interacting together.

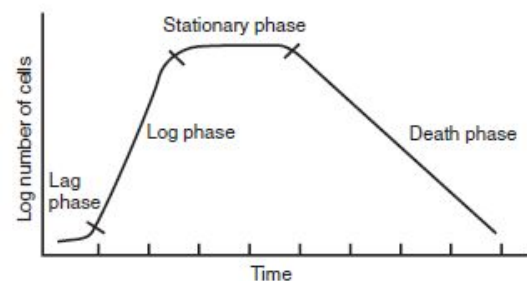
Factors Affecting Population Growth

Population size is controlled by **limiting factors**, which include:

- **Food Supply:** Lack of food will limit growth.
- **Competition:** Organisms compete for resources (food, water, light, mates, territory).
- **Predation:** The number of predators and prey affects both populations.
- **Disease:** Infectious diseases can rapidly reduce a population size.

Sigmoid Population Growth Curve

The **sigmoid (S-shaped) curve** shows the typical growth of a population in an environment with limited resources.



Phase	Description	Explanation (Limiting Factors)
Lag Phase	Slow initial growth.	Few individuals, organisms are adjusting to the new environment, and the rate of reproduction is low.
Exponential (Log) Phase	Rapid growth.	Resources (food, space) are plentiful , and the rate of reproduction is higher than the rate of death.
Stationary Phase	Population size is constant.	The population has reached the carrying capacity of the environment. Limiting factors (e.g., lack of food, increased competition, waste accumulation) cause the rate of reproduction to equal the rate of death.
Death Phase	Population size decreases.	Limiting factors become severe (e.g., resources are exhausted, high levels of waste/disease), and the rate of death exceeds the rate of reproduction.